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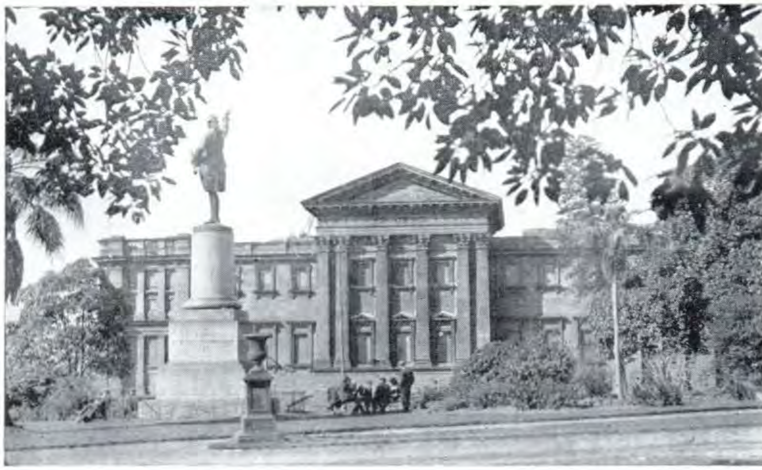

# CONTENTS



(*Photography, unless otherwise stated, is by Howard Hughes.*)

**● FRONT COVER: Cradle Mountain and Crater Lake, outstanding features of the Cradle Mountain-Lake St. Clair National Park, the largest of Tasmania's Reserves. An article on this 525-square-mile reserve, by Mr. W. F. Ellis, Director of the Queen Victoria Museum, Launceston, Tasmania, appears on page 141. The photo is by Captain Frank Hurley.**


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# *THE ORIGIN OF LIFE*


**By L. C. BIRCH**

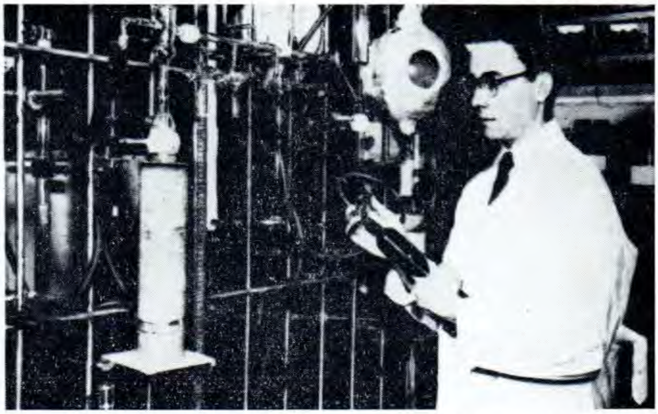
**Challis Professor of Biology, University of Sydney**


THE Cambridge biochemist, Sir Fredric G. Hopkins, ended a book on biochemistry with this statement: "The most improbable and the most significant event in the history of the Universe was the origin of life". Indeed, as we see it now, life seems to be the result of not one but several most improbable events. There was only one primordial cell from which all life evolved. There is only one chlorophyll whose reactions in green leaves feed the living world. There was probably only one sort of collection of primordial molecules which could eventually be organised into the primordial cell. There is no evidence that life today originates from the inanimate. All life comes from life today. Disbelief in spontaneous generation of life out of the dust is a central doctrine of biology. And yet it happened once, unless we are to suppose that life has always existed somewhere in the universe.

Life on this planet may not have originated here. It is possible that it came from outside planet Earth, but of that we know nothing. There are many reasons—none, to be sure, are completely convincing—that life on this Earth arose on this Earth. How can we ever begin to approach the study of so difficult a problem as the origin of life on Earth?

Two groups of chemical substances are the most characteristic constituents of living things as compared with non-living things. These are proteins (meaning "first") and nucleic acids. The entire evolution of all organisms is determined by subtle changes in the molecules of these two kinds of substances. Life is the inherent property of certain types of molecules and aggregations of molecules of which these two are unique to living things. Living organisms can build these molecules out of simpler molecules. But the patents for doing this are still held by Nature. If we could get access to the patents, and synthesize proteins and nucleic acids outside the living cell, then we would have crossed the threshold of the mystery of life's origin.

Is it possible that the conditions on primitive Earth were such that these two sorts of molecules could arise spontaneously out of the dust? It was just this question which

Professor Harold Urey (left), Nobel prize winner, and his student, Dr. Stanley Miller (right), designed an experiment in which they tried to replicate the conditions of the Earth's primitive atmosphere. Dr. Miller is seen with apparatus in which amino acids were synthesized.

Photos.—"High School Biology" (Yellow Version) (*left*) and the American Institute of Biological Sciences.

led Harold Urey, a Nobel prize-winner, and his student, Stanley Miller, in 1953 to design an experiment in which they tried to replicate the conditions of the Earth's primitive atmosphere. (See the illustration on this page.)

Primitive Earth probably had an atmosphere of methane ($CH_4$), ammonia ($NH_3$), water vapour ($H_2O$), and hydrogen ($H_2$). This is quite different from the atmosphere of today's Earth, which is largely carbon dioxide, nitrogen, oxygen and water. Urey and Miller put all these components of the supposed primitive atmosphere into a flask. The water was boiled continuously and inside the flask there was a continuous electric discharge. This was intended to duplicate the lightning of primitive Earth. The experiment ran for a week. At the end of the week, the originally colourless solution had turned red. Miller analysed the solution and found that a great variety of molecules were present. Some of these were amino acids. This was a highly significant finding, for amino acids are the structural units or building blocks of proteins. Moreover, the material in the flask was now a suitable "broth" for the growth of bacteria. So, as the astronomer, Harlow Shapley, has said, "we could be the offspring of a rather nauseating gas and primaeval lightning". Of course, the synthesis of amino acids is a long way from the synthesis of proteins and of living cells. However, this could have been a beginning. More recently, Melvin Calvin has repeated this experiment, but using gamma radiation instead of electric discharge, and he produced sugars as well as amino acids. (See the illustration on the next page.)

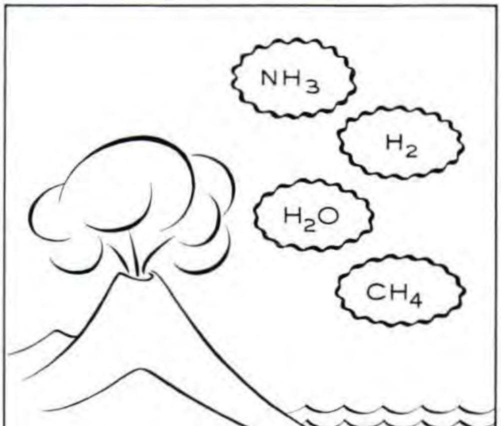
The components of such a "brew" could be expected in time to react with one another, and produce a variety of other substances. The way the first amino acids might have been tied together was suggested by Sydney Fox in 1957. He took a mixture of eighteen to twenty amino acids and heated them to the melting point. When allowed to cool, many of them had bonded together to form polypeptide molecules. These are still not proteins, but they are one step toward proteins from amino acids.

As for the other major type of molecule, the nucleic acids, some advance is being made toward their synthesis. The important nucleic acids are deoxyribonucleic acids (DNA for short). These molecules are the carriers of inherited information and the material that controls all the cell's activities. So far this molecule has been synthesized from four less complex (but still complex) molecules, provided there is present a small amount of DNA as primer.

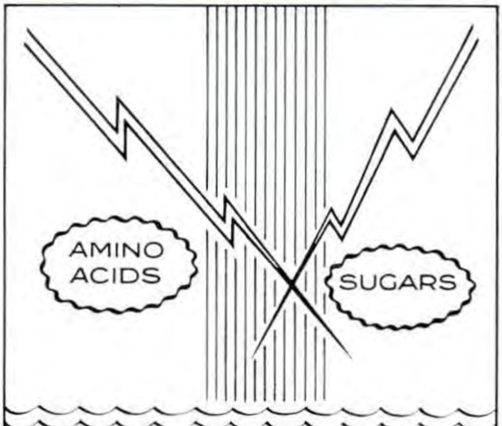
As to the next steps in the origin of life, we can only guess. The hypothesis associated with the name of the Russian, Oparin, is that life arose in just such a "brew" or soup of organic molecules formed by electrical storms. Some chance association of proteins and nucleic acids and other complex molecules, step by step, led to a complex that had the properties of self-replication. That is to say, the complex could build itself out of the raw materials. We could say that it was then alive. Perhaps it resembled a virus. A virus such as the poliomyelitis virus consists of deoxyribonucleic acid surrounded by a coat of protein. It has the property of self-replication. It can build itself out of simpler constituents, provided it is in a living cell such as in the cells of a man's brain. Viruses and genes (the heredity units on chromosomes) are the simplest self-replicating units we know of. They are living molecules.

Earth waited some 2,000 millions of years for the fullness of time for this to happen. The historic moment might have been a day, or it could have been a million or more years. Since that "moment" life has had 2,000 million birthdays. The highly improbable becomes possible, given enough time, and time there was. Perhaps life arose a number of times only to be crushed completely by accidents—"the thousand natural shocks that flesh is heir to". We might think that the destructive forces would be too great for the tiny slime of life precariously hanging on to the bottom of a shallow sea. However, it had some things on its side. The destructive forces of life today are oxidation and decay. But primitive Earth's atmosphere contained no oxygen. It was, in fact, the organisms of the Earth that placed the oxygen in the atmosphere. And as for decay, that depends upon bacteria. But they did not exist in the desolate world of the first citizen. Though easy prey, he met no enemy.

Since there was no oxygen for first life, its energy source would have to be fermentation with resulting production of carbon dioxide. Then when chlorophyll (the green of plants) was eventually synthesized, life could use the low-energy carbon dioxide to build itself. The trapped energy of sunlight was its source of energy to build complex molecules. Life might well have perished if this had not happened. In the era before chlorophyll, the soup of organic molecules may have been limited. After chlorophyll came, life was no longer dependent upon that dwindling resource, but upon carbon dioxide and simple salts which were abundant. Another important consequence of photosynthesis was the addition of oxygen to the atmosphere. This made possible the first oxygen-using life. There was no other source of oxygen but this. It has been estimated that every molecule of oxygen in the Earth's atmosphere today has arisen




PRIMITIVE ATMOSPHERE




ORGANIC COMPOUNDS FORMED

Left, the gases of the primitive atmosphere, and, right, the formation of simple organic compounds from them. [Drawings by Judith Taylor, of the Museum's Act and Design Section, based on information supplied by the author.]

from a plant at some time in the past 2,000 years.

According to this scheme, the plant-like organism came after the animal-like organism. First life fed on complex molecules. It was much later that life evolved the capacity of synthesizing all its molecules out of carbon dioxide, salts and water, as the plant does today.

The step from living molecules to living cell is a complete mystery. We do not know when or how it occurred. Perhaps this step took a thousand million years.

The scientist does not postulate any divine intervention in the origin of life. On the other hand, what he has to say is not contrary to a theistic view of the universe. It is contrary to some views of theism which postulate miraculous interventions in different stages of the creation. The scientist is saying simply that the nature of the building blocks of this universe are such that, in the appropriate combinations, they possess the property we call living. That is the shore the scientist takes us to. From that shore the philosopher and theologian may go sailing to their hearts' content.

### SUGGESTIONS FOR FURTHER READING

**Oparin, A.** (ed.), 1959: "The Origin of Life on the Earth." (Reports on the international symposium of August, 1957, in Moscow.) (Academy of Science, U.S.S.R.)

**Gaffron, H.,** 1960: "The Origin of Life." (In "The Evolution of Life", ed. Sol Tax, University of Chicago.)

This photo shows two *Cerianthus* anemones (the topmost animals) and at least 15 *Phoronis* worms (the other dark animals) associated with them in a clump around the anemones' tubes. Such associations of worms and anemones have been constantly reported by skin-divers in certain areas of Sydney Harbour and an example of it was found in Cockburn Sound, Western Australia, by some skin-divers from the Zoology Department, University of Western Australia.

The *Cerianthus* secrete a loose-fitting, slimy, felted tube of mucous around their columns. It is an opaque-grey in colour, has the appearance of felted cobwebs and is exceedingly tough. The outside of the tube is generally covered by sand grains. The anemones are taken on a sandy bottom, in several fathoms. The specimens illustrated have been brought to the surface and photographed in a shallow pool. Because of disturbance they are not fully expanded.

Projecting from the matrix of the anemone-tube and mucous coat added by the worms to it are the dark feathery lophophores of the Phoronid Worms—double, horseshoe-shaped bunches of food-gathering tentacles—that slightly resemble feather-dusters in appearance. When removed from its tube, *Phoronis australis* has a body shaped like a miniature baseball bat with a crown of dark tentacles like a ruff round the top of the "handle". It grows from 6 in. to 7 in. in length, and has a peculiar U-shaped digestive canal, as well as other peculiar bodily structures relating it, on the one hand, to the Bryozoa (Sea Mats) and, on the other, to those primitive forerunners of the backboned animals, the Pterobranchs (*Cephalodiscus*) and Acorn Worms (*Balanoglossus*). Like many sedentary marine animals, *Phoronis* is hermaphroditic.

The free, projecting portion of the *Phoronis* is a dark melanin-black, which shades off into a pale salmony-pink or orange in those parts of the body lying buried in the *Cerianthus* tube. A pale, but distinct, grey or whitish stripe, about 1 mm. wide, rings the body near its posterior extremity. Each *Cerianthus* seems to have a number of *Phoronis* attached to its tube.

Less than 10 species of Phoronid Worms have been described so far from all over the world. It will be interesting to see if exploration by skin-diving zoologists will discover more. (Photo.—Isobel Bennett.)

E.C.P.

Dove Lake, from Cradle Mountain. [Photo: Captain Frank Hurley.]

# *The Cradle Mountain-Lake St. Clair National Park, Tasmania*

**By W. F. ELLIS**

**Director, Queen Victoria Museum, Launceston, Tasmania**

TASMANIA is well known for its crops, particularly apples, hops and potatoes, but, in reality, a much greater part of the island is permanently assigned to national parks, sanctuaries and reserves than is used for cultivation. In all, these reservations cover 1,000 square miles or one-twenty-fifth of the whole State, and within them exploitation of the animals, plants or natural formations is totally forbidden.

Thus, the rugged features, which were once a major obstacle to the State's progress, have been transformed into one of its richest assets. Complete zones of forest, lake, mountain and coastline are preserved for the future, as well as separate caves, floral reserves, animal sanctuaries, scenic roads and so on.

The Cradle Mountain-Lake St. Clair National Park is by far the largest of these parks; its 525 square miles alone comprise about two per cent of the whole State. Situated near the centre of Tasmania, it extends from six miles north of Cradle Mountain to three miles south of Lake St. Clair, a total distance of nearly fifty miles, varying in width between eight and twelve miles. It is served by good roads to Waldheim, near Cradle Mountain, and to Lake St. Clair, and accommodation huts and chalets are provided at each entrance. Conventional wheeled vehicles cannot go much farther into the Park, however, access thereafter being by foot-tracks. The main overland track, fifty-six miles in length, is provided with shelter huts every seven miles or so, and from this route side tracks lead to the rest of the Park. For those in reasonable health, the available routes vary from easy to difficult according to the detours which are attemped.

The Park varies in altitude from 2,300 ft. to 5,305 ft. Fifteen of the mountains in it are more than 4,000 ft. in height. The rainfall is high (more than 100 in. a year at Cradle Mountain), with heavy snow during the winter, making this area the source of five of Tasmania's main rivers. Hundreds of lakes and tarns are also to be found, from small ponds to Lake St. Clair itself, which is about ten miles long.

**Exploration**

This area was first explored in 1827 by Henry Hellyer, a surveyor employed by the Van Diemen's Land Company to locate land suitable for grazing. Another of the company's surveyors, Joseph Fossey, was probably responsible for naming Cradle Mountain after its resemblance to a prospector's cradle. The mountain was first scaled in 1831 by Hellyer.

Though scenically magnificent, the deep glacial valleys and towering peaks were of no use for agriculture or grazing, and the area remained unoccupied and unvisited by all except a few trappers and prospectors. Some small mines were opened between 1890 and 1920, producing coal, copper, tin, lead, silver and tungsten ores, but high costs eventually closed them all. Transport was still the main problem, for there was no real access at all. Then, in 1909, a pack-horse track was opened, and, beckoned by the striking profile of Cradle Mountain, a few enthusiastic amateur explorers began to arrive—among them being Gustav Weindorfer.

**Gustav Weindorfer's Work**

Weindorfer was an Austrian who had retired from an Austrian shipping company to take an Australian wife and become a farmer in northern Tasmania. After several visits to the Cradle Mountain area, Weindorfer decided to build an alpine chalet such as he had known in his homeland and, as his own architect and builder, the work was commenced in 1912, using the native pines found on the site. He and his friend, Major R. E. Smith, had little difficulty in securing by lease and purchase extensive areas of this then unwanted land.

Even then, they envisaged the chalet as the nucleus of a vast National Park, which it was to become. "Cradle Mountain," he wrote, "appeared to me as a veritable El Dorado for the botanist," and his enthusiasm never diminished. He was a keen botanist,

The Artists' Pool, a beauty spot at the foot of Cradle Mountain (background). [Photo: Captain Frank Hurley.]

having several scientific publications to his credit, and commenced studies of the animals, plants and meteorology of the area which continued during the remainder of his life. Tirelessly, he lectured and wrote to promote the development of a National Park

The Cradle Mountain Trailside Museum is intended to serve as a summary of the natural history of the Cradle Mountain-Lake St. Clair National Park. Below: Some of the 5,000 people who have already visited the Museum since it was opened ten months ago. The exhibits are entirely open, there being no glass barriers to come between them and visitors. The Museum is conducted as a branch of the Queen Victoria Museum, Launceston, in association with the park's board. [Photos: E. Vogelpoel.]

and the conservation of its many unique features, and gradually he was rewarded by wide support. Roads and tracks were developed and the Park was proclaimed a permanent scenic reserve on March 27, 1927.

Weindorfer died on May 5, 1932, and is buried near his old home, which became a Government Chalet.

**Animals And Plants**

Today, the Reserve has become a kind of organic museum, where animals, plants and rocks are shown in a living relationship with one another. Among the deeply-dissected plateaus, moraines, erratics, cirques, glacial lakes and valleys are everywhere, as evidence of the vast rivers of ice which ground through here in the Pleistocene period. In the tarns and streams may be found the Mountain Shrimp (*Anaspides tasmaniae*) which, with three other species, is a living representative of a Carboniferous crustacean. The Platypus (*Ornithorhynchus anatinus*) is common here, as is also the endemic Tasmanian Spiny Ant-eater (*Tachyglossus setosus*). Many of the marsupials have become quite tame and, though living in the bush, readily come forward to watch humans and to be fed, even the ferocious Tasmanian Devil (*Sarcophilus harrisoni*). In more remote parts of the Park unconfirmed sightings of the wolf-like Tasmanian Thylacine (*Thylacinus cynocephalus*) have been reported from time to time.

Plant life varies widely with the environment. On the high, exposed mountain tops, where snow lies for months each year, the "cushion plants" are of particular interest, growing into rounded mounds up to 3 ft. in diameter. In the valleys and plains, where waterlogged soil is found, the button-grass communities dominate, the dense tussocks rising to 6 ft. in height. Elsewhere, the palm-like *Richea pandanifolia* abounds, one of the eight species of this genus to be found only in Tasmania. The endemic conifers Celery-top Pine (*Phyllocladus asplenii-folius*), King William Pine (*Arthrotaxis selaginoides*), Pencil Pine (*A. cupressoides*) and *A. laxifolia* are also still fairly common. In autumn, the unusual deciduous beech, *Nothofagus gunnii*, shows as a clear red scar in the green bush, while the commoner Southern Beech (*Nothofagus cunninghami*), sometimes reaching 150 ft. in height, forms forests in which the small leaves blend together, completely excluding the sun. Individual trees reach a girth of 20 ft.

**Trailside Museum**

In May, 1962, the Cradle Mountain Trailside Museum was opened at Waldheim, representing the completion of a project commenced twenty years previously but suspended during the last war.

It is operated, as a branch of the Queen Victoria Museum, Launceston, in association with the Cradle Mountain-Lake St. Clair National Park Board, and is intended to serve as a summary of the natural history of the Reserve and a key to its features for those walking through it.

Facilities are also being installed to make the Museum a modest field station from which detailed studies of the area will be made.

The Museum is housed in its own building, 30 ft. long and 15 ft. wide, which, like Waldheim Chalet, is designed to blend into the surrounding bush. Inside, exhibits on the animals, plants, geological and physical features of the Reserve are presented in open displays, without any glass barriers. Several thousand people have already visited the Museum during the winter and spring, and their appreciation of its open displays is shown by the fact that none of the exhibits have been damaged.

# *THE RINGTAIL POSSUM IN SOUTH-EASTERN AUSTRALIA*

By J. A. THOMSON and W. H. OWEN
Department of Zoology, University of Melbourne

ONE of the most familiar of the native mammals of eastern Australia is the Ringtail Possum (*Pseudocheirus peregrinus*). The tree-dwelling marsupials—the possums, cuscuses, gliders, koala and so on—are generally so strictly nocturnal in their habits that they are seldom seen, unless, as in the case of the Brushtail Possum, their destructive or noisy habits force attention on them.

That the Ringtail Possum, in its natural state, should be more familiar to most of us than many of its relatives is due to two important feaures of its natural history, the conspicuous nest and wide distribution. The nest, or to use the older term applied to squirrel nests in Europe, the drey, is a spherical structure often conspicuously placed in the branches of shrubs or trees. It is about ten inches in diameter and has a single circular aperture placed in the side. The drey is composed of leaves or twigs woven tightly together and lined with eucalypt or tea-tree bark, and sometimes with fern, grass or moss. Ringtails also place their nests in hollow eucalypt spouts or stumps if these are available. Nesting material is carried in a bundle held by the tail, often for quite long distances; it is frequently possible to see from above, but not below, the bared runways along the branches of eucalypts which mark the site of bark-collecting activities. Both male and female participate in nest building, which may be carried out at any time of the year.

The distribution of the Ringtail includes a wide variety of communities, ranging from coastal and inland scrubs to sclerophyll forest and the edges of the snow-gum stands in the highlands. This wide distribution in itself is of considerable interest to the ecologist analysing the population structure of the species.

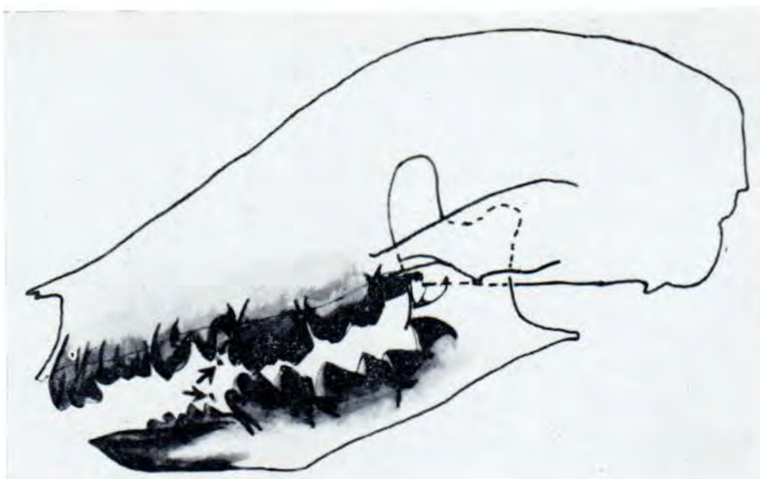
### Dependence On Eucalypts

Nearly all our possums and their relatives (except secondarily the extremely adaptable

A Ringtail Possum using its tail to carry nesting material—twigs, leaves and pieces of bark. [Drawing by E. B. Le Page.]

Brushtail, and some specialized northern species) are dependent on eucalypts for either food or shelter or for both. The koala and the Greater Glider (*Schoinobates*), for example, feed exclusively on ecualypt leaves. Other species, such as the Sugar-glider (*Petaurus*) or the Feathertail Glider (*Acrobates*), feed on insects as well as on the leaves, sap and blossoms of the gum-trees. All these, however, are dependent on the ecualypts for shelter, as only these trees provide adequate hollow limb spouts and trunk cavities in which the nests of these animals are found. The wide geographical range of the Ringtail Possum may well be related to its ability to build nests in open branches as well as to its use for food of the foliage of a variety of shrub species in both coastal and inland associations where eucalypts may be either sparse or absent altogether. The Western Australian Honey-possum (*Tarsipes*) also builds nests in the branches of coastal shrub species such as the tea-trees, but most other possum species prefer to make their nests in hollows rather than in open branches.

Perhaps unexpectedly, the koala is a closer relative of the Ringtail Possum than is the superficially more similar Brushtail Possum. The Ringtail and the koala share a number of characteristics, such as their ability to use, in climbing, the thumb and next finger of the hand against each other to gain a grip, and the crescent-shaped ridges running along their molar teeth. Neither of these features is seen in the Brushtail. A further striking reflection of the relationship of the koala and the Ringtail is found in the history of the milk dentition, of which only one upper and one lower tooth is ever represented in the marsupials, whereas in man and many other placental mammals there are a number of such deciduous teeth. In the Ringtail and the koala, the milk teeth are present as tiny calcareous bodies in the gum of the pouch-young, but they never break through the gum and never become functional. The Brushtail, on the other hand, has two quite well developed milk teeth which are used by the young animal



Vestigial upper and lower milk premolars (arrowed) of the pouch-young of the Ringtail Possum, aged about 90 days. These teeth never break through the gum. [Drawing by E. B. Le Page from a radiograph prepared by the Commonwealth X-ray and Radium Laboratories.]


The lower jaw of a young Brushtail Possum, showing replacement of a functional milk premolar by a tooth which has formed below it. [Photo: R. J. Oldfield.]

for chewing in the ordinary way until they are gradually pushed out and replaced, before sexual maturity, by the permanent teeth developing below them.

**Study Of Ringtail Possums**

For over two years now we have been studying the social organization and breeding patterns of Ringtail populations in east-central Victoria. It is only to be expected that there will be minor differences between the populations we have studied, and others in different areas. In our principal 60-acre study plot we have ear-tagged the possums so that they can be recognized individually. There is little migration to or from the area, although there is a high population turnover—that is, both a high birth-rate and a high death-rate. The vegetation of this plot consists of mixed scrub and dry sclerophyll woodland, consisting mainly of the tea-trees *Kunzea* and *Leptospermum*, with peppermint (*Eucalyptus radiata*) and messmate (*E. obliqua*). This community supports an average of one Ringtail per acre. Extensive surveys in dry sclerophyll forest have provided evidence that such country supports over all a much lower population density than our small study area, perhaps about one possum to ten acres on the average. Where patches of understory scrub are well developed in such forest local concentrations of Ringtail Possums are found. As the favoured shrub species are found mostly along watercourses, the more dense populations of the possums tend to show riparian distribution. Wet sclerophyll forest, chiefly of Mountain Ash (*Eucalyptus regnans*), carries only about one-third of the Ringtail density of the drier forests. Coastal tea-tree (*Leptospermum*) scrubs generally compare quite favourably with inland scrub-woodland communities.

**Strictly Vegetarian**

The Ringtail is a strict vegetarian, feeding on the leaves, shoots and berries of a wide range of shrubs, and also on the foliage of eucalypts. Insects apparently never constitute an important element of the diet. There is a marked seasonal change in body weight, presumably reflecting, at least in part, seasonal differences in the quantity and quality of food available to the possums. The live weight of tagged animals under study in the field increased throughout life until the possums lost weight in senility, but during the summer months condition was usually temporarily lost. Evidence was also found of possible annual differences in the nutritional status of the possums. Animals of particular age-groups were consistently heavier in the spring of 1960 than were their counterparts in 1961. Spring of the latter year was particularly dry, only about half the average annual rainfall for this period being recorded in the study area. During 1960, on the other hand, a spring rainfall of double the average figure provided exceptionally good conditions for plant growth.

Apart from the possible effect of food supply in determining the distribution and abundance of the Ringtail, the availability of nest sites also seems to be important. Forest communities often show poor development of understory species offering suitable support for the Ringtail nests, except along the banks of streams. Few nesting sites are then available for Ringtails unless the dominant tree species readily develop spouts, or unless, through fire damage or other cause, dead hollow trees have been left standing. In our Victorian study area, 90 per cent of all nests built in eucalypts were situated in mistletoe (*Loranthus*) clumps parasitizing the trees; the branching pattern of eucalypts does not generally provide sufficient support for the Ringtail drey. Although nests in eucalypts comprised only a small percentage of the total number of nests seen in this area, other localities have been visited in which virtually every Ringtail nest was situated in a mistletoe growth. Unlike the Brushtail Possum, the Ringtail apparently seldom, or never, eats the leaves or fruit of the mistletoe, but probably transports on its hair the sticky seeds wiped onto branches by birds feeding on the fruit. There is little reason to doubt that in a number of eucalypt woodland communities the distribution and abundance of the Ringtail are largely determined by the distribution and abundance of the mistletoe!

**Breeding**

Ringtail Possums begin to breed early in May. The pouch contains four nipples, and litters vary in size from one to three, the average being two. The posterior pair of teats is favoured; attachment of the new-born to either of the anterior pair is much less frequent. The breeding season is long, births commonly occurring up to September, by which time almost every sexually mature female in the population is carrying pouch-young. If for any reason the entire litter is lost, a second pregnancy occurs and the lost offspring are replaced. In one case a birth recorded in November provided evidence that, rarely, a second litter may be carried in one year. The young of the first litter had vacated the pouch, allowing the attachment of the later young to an undistended nipple. The first offspring were, however, still being suckled periodically from outside the pouch, a situation quite common amongst the kangaroos.

The young remain in the pouch for about four months. Females carrying young are quite gregarious, and up to five possums of different ages and both sexes may share the same nest. Frequently each "nest-group" of animals shares from two to four different nests, all situated within a relatively small area and all kept in good repair, the possums resting in any of these during the daytime. It is for this reason that so many empty dreys in good repair are seen when a nest census is made. After the offspring leave the pouch, but before they are weaned, they are often left alone in a nest during the day while the mother rests elsewhere. The young usually breed in the first year after birth.

**Life-Span**

The maximum life-span of the Ringtail Possum in wild populations is approximately four years, but this is highly variable. The average life-expectancy of any individual is obviously much less, due to the dangers of natural death through accident, disease or predation.

The most important predators of the Ringtail Possum in south-eastern Australia are the cat (both domestic and feral), the fox and the Powerful Owl (*Ninox strenua*). The Powerful Owl appeared to be the most consistently destructive during our investigation. Once the favoured roost trees of the owls have been identified, it is possible to watch them regularly, and to inspect the ground below for the tell-tale remains—the tail and a flap of skin containing the musky anal glands of the possum.

As continued agricultural development destroys more and more of the natural habitats of our native animals, it will become increasingly important that we study in the field the factors which determine the distribution and abundance of these species. Only then will we be able to ensure their survival, either by habitat conservation or by other appropriate management techniques.

## *REVIEW*

**HELICTITE—JOURNAL OF AUSTRALIAN CAVE RESEARCH, edited by Edward A. Lane and Aola M. Richards, Sydney, to be published quarterly. Vol. I, No. 1, October, 1962; pp. 1-20, offset process, subscription £1 per annum.**

This new journal is the first periodical in Australia devoted entirely to cave *research* as distinct from numerous local speleological society newsletters which feature members' explorations and observations. The scope of "Helictite", as described in the editorial, is to be wide, "ranging from the scientific study of caves and their contents, to the history of caves and cave areas, and the technical aspects of cave study and exploration. It will also include fringe subjects such as rock paintings and excavation of rock shelters. . . . The territory to be covered incorporates all Australasia in the truest sense—Australia, New Zealand, the near Pacific Islands, New Guinea and surrounding areas, Indonesia and Borneo".

Scientific interest in Australasian caves and cave fauna, past and present, has increased considerably over the past few years, and because of this the editors felt such a journal would provide a vehicle for the publication of papers which might otherwise be scattered through a series of obscure, or unsuitable, publications. Useful as this new journal may prove to be, one cannot help feeling that the editors have set a very high publication rate, four numbers a year, in a rather small and specialized field. The first number has a review article on the environment of cave animals, with discussions of meteorological conditions, ecological classifications of cave animals, physiological adaptations and the origin of cave fauna; this is followed by an evaluation of the detailed geological observations of the Rev. Julian Woods on South Australian caves, originally published in 1862, and, finally, abstracts of two papers published in overseas journals on new Carabid cave beetles from Australia and New Zealand. The reviewer notes that *Notospeophonus castaneus* Moore is the first cavernicolous Carabid from Australia, a fact otherwise rather lost in the original publication.—J.C.Y.

A New Zealand specimen of the giant deep-sea prawn *Notostomus*, entirely blood-red in colour and about 8 in. in length. Note the complex sculpturing of the surface of the cephalothorax (the fused head and thorax). [Photo: M. D. King.]

# *Deep-sea Prawns—Their Colour and Luminescence*

By J. C. YALDWYN

BELOW the depth to which visible light penetrates in open ocean waters (about 1,500 ft. in reasonably clear conditions) is a region of perpetual darkness called the Aphotic zone. There in the oceanic mid-waters, below the lighted surface layers and above the colder bottom waters, is the realm of the bathypelagic fauna (the free-swimming and floating animals of the deep sea, from the Greek words *bathús*, deep, and *pélagos*, open sea), sometimes popularly called the "black fish-red prawn" zone from the typical colours of the two dominant animal groups caught there by oceanographic apparatus. As recently as the 1840's distinguished scientists in many countries believed that life could not exist in the deep sea below a level of about 300 fathoms (1,800 ft.). They claimed that, below this hypothetical depth, there existed the Azoic (lifeless) zone. We now know that a great diversity of life exists down to the greatest depth investigated by man, that is 5,500 fathoms (about 38,500 ft) in the famed Philippine Trench to the east of the island of Mindanao.

In this bathypelagic zone live a large number of free-swimming shrimps and shrimp-like crustaceans, the majority being entirely bright red—descriptions such as vivid scarlet and blood red have been used. Those not of a uniform red are partially red and partially transparent. Common forms distributed all over the world's oceans, including the Indian Ocean and Tasman Sea, are species of the true shrimp or decapod group, including such genera as *Acanthephyra, Notostomus, Oplophorus* and *Sergestes,* as well as species of the shrimp-like mysid genera *Eucopia* and *Gnathophausia.* Following the usual Australasian and English usage, the large decapod shrimp, usually with a prominent anterior toothed rostrum, will be referred to as prawns; the term is rarely used in America.

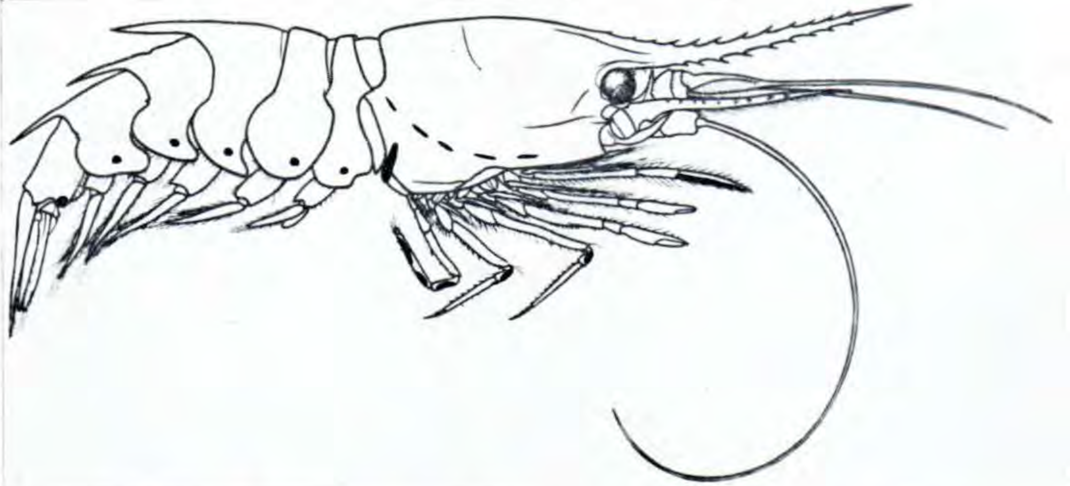
The bright red colouration is due to carotenoid pigment distributed over the surface of the prawn, immediately underneath the transparent cuticle, in a dense overlapping and interlocking network of individual, many-branched pigment cells called chromatophores. In many species the cuticle as well is tinted red but remains transparent. Chromatophores in shallow-water Crustacea often carry a variety of different coloured pigments and are capable of contraction and expansion under the control of the animal, thus producing various changes of colour pattern. It is doubtful, however, if the deep-sea prawns can contract their chromatophore network in this manner. Although this red colouration contrasts so strikingly at the surface of the ocean with the black melanin pigment of the majority of the fish present in this zone, it is a fact that the red and orange rays of the light spectrum are absorbed by the increasing depth of the water much more quickly than the blue and violet rays. Thus, in the depths below the penetration of the red rays the scarlet prawns will appear just as black as the melanin-pigmented fish.

**Production Of Light**

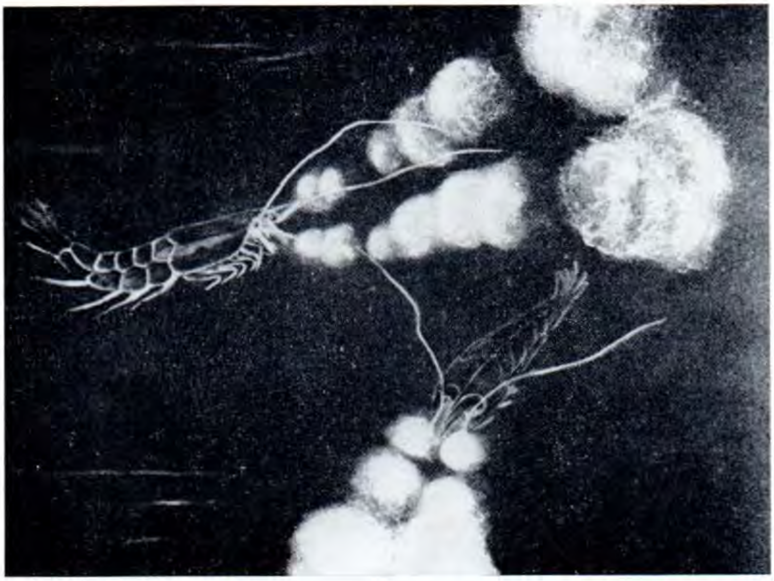
Now as well as being bright scarlet in colour many of the prawns can also produce, apparently at will, certain types of light by several different methods. Without going into details, the light can be produced by

- Distinct organs called photophores, often with their own external lenses, and often blue in colour, associated with an internal pigment screen;
- Internal light-producing organs, such as the so-called organs of Pesta which are pigmented and modified areas of the liver named after their discoverer, and
- Ejection of a "luminous cloud". This is the discharge from glands near the mouth of a cloud of luminous matter producing a momentary but brilliant flash of light.

The light produced by these three methods, as well as all the light produced by living animals of various kinds, for example glow-worms, fireflies, lantern-fish, etc., is a cold light or a luminescence, that is, light produced with almost no loss of energy as heat. In most forms of man-made illumination (incandescence) more than half the energy is wasted as heat, whereas in the glow-worm it has been shown that only about 1 per cent is so lost. Animal cold light, as well as that produced by some bacteria and plants, is known as bioluminescence, though the term phosphorescence is often loosely used in this meaning, especially when referring to the general "phosphorescence" of minute organisms in the sea. This latter



*Oplophorus spinosus, one of the best-known bathypelagic luminous prawns.* The approximate distribution of the lens-bearing photophores is shown. [Modified after Chace.]



An artist's representation of "luminous cloud" light production in a deep-sea prawn. [After Dahlgren.]

term is best used only in the sense of the physicist, namely, the absorption of radiant energy by substances which then give it off as light. An example of this is the luminescence of a wrist-watch dial. This is a special type of phosphorescence called fluorescence due to the effect of the radioactivity from a trace of radium on the zinc sulphide in the paint.

**Chemistry Of Bioluminescence**

These bathypelagic prawns are by no means the only Crustacea able to produce light, but they are perhaps the most interesting due to their relatively large size, up to about eight inches, and to the spectacular nature of their luminous cloud production. The chemistry of bioluminescence is by no means fully understood, but it appears that in all cases it is due to the reaction of luciferin with oxygen and water in the presence of an enzyme, luciferase. The extra energy is given off as light, a mere by-product in this unusual reaction. Little is known of the structure of either luciferin or luciferase, but the latter is a protein, and luciferin is a complex substance apparently in a different form specific to each different organism in which it is found.

A simple and practical use for the chemical action of bioluminescence was devised by the Japanese Army during the Second World War when officers used the small ostracod crustacean *Cypridina* as a source of low-intensity illumination. At night, under combat conditions, where the use of conventional light for reading of messages or maps would be unsafe, the officer placed a small quantity of dried and ground *Cypridina* powder in the palm of his hand, moistened it and read the message by cold *Cypridina* light, which would last for a few seconds to a few minutes according to the amount of powder used.

**Author's Observations**

The striking and almost unearthly nature of the luminous cloud bioluminescence is best illustrated from notes made by the writer when he was privileged to observe this rarely-seen phenomenon at sea across the Tasman off New Zealand on March 31, 1956. A team from the Zoology Department of Victoria University of Wellington, working on a long-term biological survey of the deep waters of the Cook Strait canyons, had just brought a six-foot-diameter cone net to the surface at about 5.40 a.m. to complete station 57, a three-hour haul made at a depth of about 300 fathoms (1,800 ft.) over a bottom of at least 1,200 fathoms. A partially bright red and partially transparent four-inch prawn, *Oplophorus novaezeelandiae*, carrying about a dozen large red eggs under the abdomen, was picked out of the catch still alive and undamaged and placed in a bucket of sea water on the deck with other material from the net. A few minutes later another animal from the catch was dropped into the water and immediately the prawn discharged a vivid cloud of luminous material. The matter could be seen billowing out from the vicinity of the gills and extending slightly more than the prawn's length anteriorly. This cloud appeared to be non-particulate and, though the light clearly illuminated the contents of the bucket, it rapidly faded and in a few moments was not visible. The prawn repeated this luminous discharge, apparently spontaneously, twice more within the space of a few minutes, all three clouds being about the same size and intensity. On being taken from the water a few minutes later it repeated this phenomenon and the luminous material was seen clearly to originate near the anterior apertures of the gill chambers, then to flow over the writer's wet hand and on to the deck.

This prawn had 42 lens-bearing and pigmented photophores placed in a pattern across the side of the cephalothorax, behind the legs, under the abdomen, on the eyestalks and on many of the segments of the legs themselves, but at no time during the above observations were these seen to emit light. The distribution pattern of these photophores is very similar to that illustrated here for another species of *Oplophorus* taken in the deep waters of the North Atlantic, off Bermuda, by the late William Beebe, of bathysphere fame.

**Beebe's Descents**

Beebe was the first man to observe bathypelagic animals in their own habitat when he made a series of descents with Otis Barton and others, in a specially designed steel sphere, down to a maximum depth of 3,028 ft. (a little over 500 fathoms) between 1930 and 1934. These dives were all made within an eight-mile circle a few miles off the coral reefs of Bermuda over a depth of 1,000 fathoms and more. The bathysphere descents were only part of the intensive investigations made on the animals of this eight-mile-wide, mile-and-a-half-deep cylinder of water over a number of years by the New York Zoological Society and the National Geographic Society under the direction of William Beebe.

Through the thick quartz windows of the bathysphere he was able to observe luminous cloud production on many descents, and gives the following descriptions in his popular book "Half Mile Down":—

"Luminescence was repeatedly observed. Two general kinds were produced, one type, by the photophore-like luminous spots characteristic of all euphausids and a few shrimps, and, another, by a discharge of luminous fluid . . . the luminous matter was obviously discharged only when the shrimp was startled, as when it bumped against the bathysphere window. When this happened, a rocket-like burst of fluid was emitted with such violence that the psychological effect was that of a sudden explosion . . . For an instant the shrimp would be outlined in its own light—vivid scarlet body, black eyes, long rostrum—and then would vanish, leaving behind it the confusing glow of fluid . . . in the laboratory a dying shrimp has sent out a luminous puff . . . but the flash was only momentary and not to be compared with the feeblest of the displays seen from the bathysphere."

**Functions Of Luminescence**

The use of luminescence by deep-sea Crustacea is largely a matter of speculation. Among the functions suggested by various writers are: (1) illumination of the ocean depths, in other words lighting and extending the visual field of the animal; (2) to lure or attract prey within reach of the light-bearer; (3) to act as species-recognition signs to facilitate schooling (this presupposes a different photophore pattern for each species, which, in fact, has proved correct); (4) to allow sexual recognition, or recognition of the state of maturity (this presupposes some sexual difference in photophore pattern and this has not been observed yet in deep-sea prawns, though sexual differences in intensity may very well exist), and (5) to confuse or momentarily blind an attacker. This use has especially been put forward for luminous cloud secretion, which perhaps may be the functional equivalent of the ink cloud discharged by a disturbed octopus or squid. On the other hand, perhaps our everlasting search for function in the biological world may, in this case, be misapplied, and might not bioluminescence in decapod Crustacea be merely an "ornamental", physiological rather than structural, extravagence?

Folded argillaceous limestones, probably of Cambrian age, four miles east of Nepabunna Mission Station on the road through the Flinders Ranges from Copley to Balcanoona. [Photo: Ben Flounders.]

# *Minerals of the Mt. Painter Country*

By R. O. CHALMERS

THE most mountainous region of South Australia runs almost continuously for 500 miles from Kangaroo Island through the Mt. Lofty Ranges immediately to the east of Adelaide, and through the Flinders Ranges, which end in the north near Marree. The southern end of the Flinders Ranges was first discovered in 1802 by Flinders when he was charting Spencer's Gulf.

The rocks throughout the entire length of these highlands consist of shales, sandstones, limestones, quartzites, slates and tillites (glacial deposits). The total thickness is very great, no less than 50,000 ft. These rocks were formed from the accumulation of vast amounts of sediments deposited in a huge, elongated, slowly-sinking marine trough from late Pre-Cambrian time (800 million years ago) to the Cambrian (500 million years ago). The Pre-Cambrian section of the sequence is known as the Adelaide System.

After Cambrian time, great earth movements crumpled these rocks and built them into a great system of folded and faulted mountain chains.

With the possible exception of the interesting fossil jelly-fish and worm-like creatures in quartzite at Ediacara, between Beltana and Lake Torrens, there is no evidence of fossils in this great thickness of sedimentary rocks. In the upper part of the sequence abundant *Archaeocyatha,* a cup-shaped fossil having affinities with both corals and sponges, is found in Cambrian limestone at Beltana and Mt. Scott, near Aroona Dam.

## Rocks Of Great Age

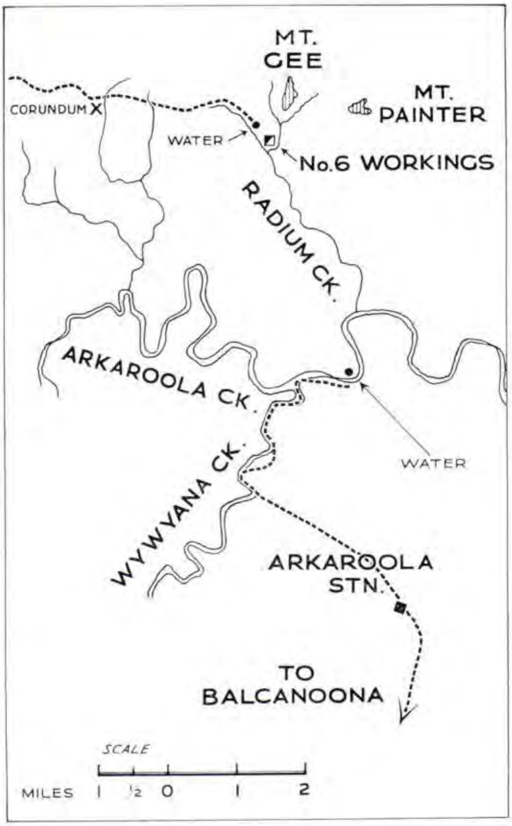
In a few scattered areas in the Mt. Lofty and Flinders Ranges the really ancient Pre-Cambrian highly-altered schists and gneisses, the crystalline core of ancient Australia, are exposed. One of these areas is the Mt. Painter region in the very far north-eastern portion of the Flinders, lying about 350 miles distant in a straight line from Adelaide and about thirty miles west of the northernmost tip of Lake Frome. The exact age of these rocks has not yet been determined, but could be as much as 2,000 million years.

It has been known for many years that Mt. Painter was a mineralogist's paradise, but it is an extremely remote and rugged region, and no one from this Museum had the opportunity of travelling there until April, 1962, when, on the kind invitation of Mr. Ben Flounders, of Whyalla, the writer was able to join a party visiting this region. Mr. Flounders, who is noted for his knowledge of geology and other branches of natural history, was the leader, and due to his knowledge of the country and his great experience in all phases of life in the outback, including maintenance and repair of vehicles, the trip was a great success.

We set out from Whyalla in a Volkswagen utility and a Land Rover, taking the north road which follows closely the picturesque route of the old narrow-gauge Northern Railway from Port Augusta, now unfortunately abandoned following the opening of the Commonwealth standard-gauge line in 1956. A brief diversion was made to see Aroona Dam and to collect *Archaeocyatha* limestone at nearby Mt. Scott. This dam supplies water to Leigh Creek, some few miles further north, South Australia's only producing coal-field.

Turning east at Copley, the entire width of the Flinders was crossed from west to east. Coming on to the plains by way of Italowie Gorge, a sharp narrow cleft in the eastern scarp of the Flinders, we saw the dazzling salt bed of Lake Frome on the horizon. At Balcanoona, sixty-two miles from Copley, the road, now turning north again, entered the far north-easterly section of the Flinders. The scenery in this remote region is on an even grander scale than further to the south. All the way from Port Augusta we had been either right in the ranges or never very far from either the eastern or western margins. We were quite overwhelmed by the wonderful scenery of these ranges, with their great rugged, sparsely-vegetated outcrops of tilted and folded rocks and vivid colours so successfully captured by the painter Hans Heysen.

The end of the road for vehicles was Arkaroola Bore, close to Arkaroola Creek, some twenty-two miles north of Balcanoona. The road(?) for the last seven miles from Arkaroola homestead is mainly along the rock bed of Wywyana Creek, and the going is pretty rough. The rainfall is somewhat higher than on the very arid flanks of the Flinders, but the annual average is still only 12 in. The sides of Arkaroola Valley are almost precipitous, but here, as in other parts of the area, the native pine *Callitris*




was reasonably abundant on the steep slopes and the creeks were fringed with Murray River Red Gums, some of them quite large. Occasionally a dense tea-tree scrub was encountered along the creeks and spinifex was often seen. The creeks are mostly dry, although flash-floods occur when heavy rain falls. Conditions were rather exceptional, due to there having been two heavy falls since December, 1961. Near our camp there was a pool big enough for swimming, and rockholes with good fresh water. There is permanent water in the bore, quite drinkable but somewhat mineralized.

**Interesting Mineral Occurrences**

Before setting out on foot for Mt. Painter, an examination was made of an interesting nearby occurrence of the mineral stilbite. This is a hydrated silicate, one of the zeolite group, and abundant masses of typical salmon-pink sheaf-like aggregates occur closely associated with dark green, glassy,

The No. 6 workings, source of some of the finest specimens of torbernite and autunite in the world, lie on the steep slopes of the conical peak of black manganic ironstone that shows up clearly in this picture. [Photo: Rex Hosking.]

columnar crystalline masses of actinolite, a variety of amphibole, and massive black ilmenite sometimes in well formed crystals. Calcite is frequently present, some of the cleavage pieces showing curvature, and in places there are also crystals and granular aggregates of deep green and yellowish-green titanite. Sometimes the titanite is pale yellowish-green, has a platy structure and is soft and fragile. These minerals occur in abundance in a mineralized zone, a wall-like mass having sharp contact with the country rocks. The stilbite-actinolite-ilmenite-rich zone cuts right across the strike of the country rock, which is an amphibolite showing the usual curving outcrops of these highly folded, late Pre-Cambrian rocks.

Mt. Painter itself lies six miles further on, and can only be reached on foot. Early prospecting in this region, as early as 1862, resulted in the discovery of copper minerals some fifteen miles north of Arkaroola Bore. Mining was carried on for many years, the most famous area being Yudnamutana. A notable figure was W. B. Greenwood, who had extensive pastoral and mining interests. In 1898 he owned both the Yudnamutana Mines and Arkaroola Station. His most notable discovery was in 1910, when he found uranium minerals, particularly the brilliant yellow autunite (calcium uranium phosphate) and brilliant green torbernite (copper uranium phosphate), near Mt. Painter. Some of the finest specimens in the world came from his deposit known as the No. 6 Workings. Outstanding specimens in the Australian Museum formed part of the magnificent collection presented by the late A. D. Combe in 1947. Arthur Combe personally collected these back in Greenwood's time. Greenwood also discovered other deposits nearby, but No. 6 was the most famous. Sir Douglas Mawson made several trips there at the time and was the first to give a scientific description of these minerals.

**Uranium Mining At Mt. Painter**

The Curies had first extracted radium from Bohemian uranium ores only eight years earlier, and Greenwood began mining the Mt. Painter uranium. He had already brought camels into this country on his other mining ventures, and it was not long before he had built a camel pad starting from the site of the bore on Radium Creek near the foot of the No. 6 Workings. This track ran out in a general north-westerly direction and linked up with another one coming in to a deposit of pink and blue corundum, some of it gem quality, that he had discovered in 1906. He brought all his stores and equipment in and packed out many camel loads of uranium ore along this track, eventually reaching railheads such as Leigh Creek, Lyndhurst and Farina on the Northern Railway Line some 100 miles away, the whole distance being over pretty rough country. Travelling between Balcanoona and Arkaroola we saw two of Greenwood's pack-camels still roaming around. They looked somewhat worn out, being at least fifty or sixty years old. Greenwood's venture into uranium mining was not an economic proposition and work stopped in 1916.

In 1944, when there was a world-wide quest for uranium for the atomic bomb project, at the request of the British and Commonwealth Governments the South Australian Mines Department prospected the No. 6 Workings and vicinity intensively and built a road in from Arkaroola Bore, but it soon became obvious that no large quantities of ore could be expected and work stopped. The South Australian Mines Department's own drilling and mining program carried out in the East Painter area, which we did not visit, between 1946 and 1950, likewise met with failure.

On our walk into the Painter country we followed the Mines Department road, but the only trace of it was along the fairly wide banks of Arkaroola Creek. On Radium Creek it took the only possible route along the creek bed. Severe floods in the late 1940's washed it right out, and we made a laborious journey along the creek bed strewn with boulders, many of them quite large. After the brief burst of activity in 1944 the area is reverting to its original primitive state, and few now penetrate it.

**Pre-Cambrian Rocks**

We were now in the ancient Pre-Cambrian rocks. Great blocks of gneissic granite studded the 500-foot-high vertical valley walls and shone with a vivid reddish-brown colour in the brilliant, clear sunshine. When the granite gave place to schists the valleys opened out somewhat, but the country was still very rugged. Our first glimpse of Mt. Painter was looking up a side creek, and a most imposing peak it is, somewhat resembling the Matterhorn from this particular angle. A mile or so further along Radium Creek brought us to the foot of a steep conical hill of very hard black manganic ironstone. A climb of 200 feet and we were at No. 6 Workings. From the dumps outside the tunnels driven into the side of the hill we collected many good torbernite specimens, but very little autunite. A short excursion was made into the main tunnel but it didn't seem very safe, so we beat a retreat despite protests from the most reckless member of the party. From the top of the manganic ironstone outcrop we had a superb view of Mt. Painter (height 2,592 ft.), a mile and a half away to the north-east.

Half a mile away from our vantage point and a little more to the north lay Mount Gee or Crystal Mount, which is really the

Looking south across the valley of Arkaroola Creek, to the stilbite-bearing mineralized zone against which the curving outcrops of the highly folded late Pre-Cambrian rocks suddenly terminate. [Photo: Max Bazzica.]

steep mountainous termination of Radium Ridge. On Mount Gee a most fantastic array of quartz crystals can be collected. Crystal groups occur in abundance in a variety of colours, some coated with richly coloured red and yellow oxides of iron. Observers have commented on the fluorescence and slight radio-activity of Mount Gee quartz. A fluorescent greenish opaline silica has been recorded, although not found by us. Peter Flounders, the schoolboy member of the party, found a group of green transparent quartz crystals, a most unusual colour. This and other quartz specimens were examined under a long-wave ultraviolet lamp, but showed no fluorescence. The fluorescence occurs when minute traces of uranium are contained in the quartz, and apparently it is not distributed evenly. Some of the quartz masses have been deposited in stalactitic masses around rod-like crystals of gypsum or laumontite and the subsequent removal of these has left long narrow cavities, rectangular in cross-section, popularly known as "nailholes".

Radium Ridge, Mount Gee and Mt. Painter have suffered crushing because of great earth movements. The fissures produced have given easy access to hot silica-bearing solutions from deep-seated sources, and in these this great variety of quartz in various forms has been deposited. The going was hard in the climb up the steep sides of Mount Gee but the reward came in the form of a magnificent view of the dry salt bed of Lake Frome, seen away to the south-east over the tops of the rugged hills. Similar quartz is found on Mt. Painter, but time did not permit climbing the mountain on this trip. Plentiful good water was found in the bore on Radium Creek at the start of Greenwood's old camel pad, but this might not be a permanent feature, so water should always be carried in from Arkaroola Bore.

As we plodded back there, tired and laden down with packs full of mineral specimens, we were none the less pleased with the results. The Museum is indebted to all the members of the party, which, apart from Ben Flounders and the writer, consisted of Jack and Peter Flounders and Max and George Bazzica. They showed unstinting effort in collecting and carrying specimens back to the base camp. Phil Edwards, owner of Arkaroola Station, was very co-operative as we passed through, both going and coming back.

# *REVIEW*

**JOURNAL OF THE ENTOMOLOGICAL SOCIETY OF QUEENSLAND, Vol. 1, 1962; to be published annually by the Entomological Society of Queensland; price 25/-; pp. 1-62.**

By the publication of the first issue of this journal, the Entomological Society of Queensland has removed a long-standing reproach to entomology and entomologists in Australia.

As pointed out in an editorial, Australia has been the only major country without an entomological journal, and because of the outstanding interest of the Australian insect fauna this lack has been deplored by entomologists in other parts of the world.

The editor expresses a hope, which the reviewer shares, that this journal will be the forerunner of one to be sponsored by a society of Australian entomologists, for which there is clearly a very great need.

It is true that such a need is not at present universally recognized by entomologists in Australia, and there are even some who hold the view that its formation is undesirable as it might prejudice the interests of existing local entomological groups. There are others who are of the opinion that such a society would be difficult to organize and conduct because of the great distances which separate centres of population. In view of the multitude of existing Australia-wide societies, such an objection carries no weight.

An Australian Entomological Society could, through its journal, not only make available to all those interested, both within and without Australia, information on Australian entomological activities, but it could also provide a forum for the discussion of entomological topics of wide, and current, interest. It would, moreover, be in a position to issue an invitation for an International Congress of Entomology to be held in Australia, and at present there is no representative body able to do this. It is quite certain that such an invitation would be widely welcomed overseas.

The first issue of this journal is well printed and contains an interesting range of varied articles. It is unfortunate that three of them happen to deal with a single family of Heteroptera, but this is not the fault of the editor, who must depend on availability of suitable material for publication.

Those responsible for the journal's production merit the thanks and congratulations of all who have the well-being of Australian entomology at heart, and the hope is expressed that their efforts will be rewarded in achieving their ultimate aims, in spite of opposition and indifference which will inevitably need to be first overcome.—J.W.E.

# *ANIMAL LIFE IN CAVES*

By BARBARA DEW

School of Public Health and Tropical Medicine, Sydney

CAVES, in popular imagination, vary from shallow sandstone overhangs to deep limestone caverns found in such areas as Jenolan, New South Wales. It is within these caves that speleologists, interested in zoology, spend their time searching for animals. These animals may be either accidental visitors which have fallen into caves or been carried in by water, or true inhabitants like bats.

Dry or dead caves, that is, those in which the formations are no longer growing, owing, perhaps to a change in the rainfall pattern, or to geological changes, support little life. Damp, humid caves, where formations are growing, and through which perhaps an underground stream may run, harbour comparatively much more life.

Biologically, there are two very distinct areas or zones within a cave—the threshold or twilight zone, and the area of complete darkness. It is of the utmost importance that these two areas are not confused during a survey. The threshold is the area limited by the distance from the entrance to which daylight penetrates, hence the popular term twilight zone.

Cave animals belong to four distinct groups, with a small degree of overlap—the accidental visitors, those of the twilight zone, those of total darkness, and the "part timers" or bats which are the most obvious and best known cave animals.

### Cave Bats

Bats play a very important part in cave ecology. Their guano, or faeces, supports a large and varied population, forming an obvious and select food chain. Huge mounds of slowly accumulated guano indicate that individual caves have been inhabited by them for thousands of years. What is not generally realized is that only a very few species of bats are cave-dwellers.

The Weta, the best-known of all cave invertebrates.

In eastern Australia, by far the commonest cave bat is the Bent-Winged Bat (*Miniopterus schreibersi*), so called because of the unusual length of the third finger. This bat is very adaptive, and has been found in man-made structures such as mines, tunnels and old houses.

Some other bats recorded from New South Wales caves are the Little Bent-Winged (*M. australis*), the Eastern Horseshoe (*Rhinolophus megaphyllus*) and the Large-footed Myotis (*Myotis adversus macropus*).

The life histories and feeding habits of most bats are incompletely known, although some progress is now being made by banding and recapture. *Miniopterus schreibersi* is known to mate during March-April, and the birth of the single young takes place from late November to early January in special breeding caves. These caves are known to occur at Wee Jasper, Bungonia and Kempsey in New South Wales, at Buchan and Warrnambool in Victoria, and at Naracoorte in South Australia. Others probably exist. The female gives birth to a single young, and, unlike some of the other species, does not carry her naked baby about while she feeds outside the cave, but returns at intervals to suckle the young. The temperature of these special breeding caves or nurseries is quite high, and the carbon dioxide concentration is also increased.

**Parasites Of Bats**

Bats, like other animals, are parasitized by ticks, mites and fleas. They are also troubled by flies which are unique and are confined to bats. There are two families of flies parasitic on bats: *Nycteribiidae* and the winged or wingless *Streblidae*. Both are highly specialized and have certain unique features. The *Nycteribiides* look rather like six-legged spiders, as they move actively around in the fur. They are yellowish-brown in colour. The *Streblids*, also yellowish-brown, can be easily distinguished by their wings, but the female of one genus of *Streblids* has degenerated into a sac-like organ which becomes encysted in the tissue of the bat, usually around the ears.

The commonest mite of the Bent-Winged Bat is a *Spinturnix* (*S. psi*), and these can often be found in numbers on the wing membranes. Bat ticks are of special interest because part of their life cycles, in common with those of all other ticks, are divorced from the host, and because the males of some of the bat ticks have not been described. The two ticks recovered from the Bent-Winged Bat are *Ixodes simplex* and *I. vespertionis*. Ticks may occur on all parts of the body, but tend to congregate around the face; the eggs, larvae, nymphs and adult males are also found in cracks and among the guano.

Apart from the bats, the majority of cave animals are small, and may easily be overlooked unless a special search is made. Most belong to the phylum Arthropoda, those creatures with jointed legs like insects and spiders.

Within the threshold area creatures which live outside caves, as well as those which have not as yet developed into fully troglodytic forms, can be found. Some of these forms may have taken up temporary residence, having sought protection from either enemies or the elements. This is often true of flies, spiders, moths, certain reptiles, marsupials and birds which have nested under the overhang. Such creatures cannot be regarded as true cave forms. However, when collections are made, it is essential to keep them separate from the forms habitating the deeper and darker recesses of the cave.

The insects and spiders of the threshold are of special interest. The commonest forms in New South Wales are the Bogong Moth, cave crickets or Wetas, numerous flies, cave spiders, one of which makes a very characteristic funnel-shaped web, and occasionally crane flies.

A moth larva in its guano-decorated case.

The Fairy Martin, the Welcome Swallow, the Rock-warbler and other birds are known to nest in caves, but usually the nests are quite near the entrance. Three exceptions to this are the Cave Owl and Falcon from the Nullabor Plains, and a New Guinea Swiftlet, all of which nest in total darkness. All these birds may be parasitized by their own host specific ticks and other ectoparasites which can also be found in caves.

In the zone of total darkness, the zoologically-inclined speleologist begins his search in earnest, and he is often faced with problems. Some areas seem to be almost completely devoid of life, and yet others especially if they are bat chambers, contain an amazing variety of small creatures. Usually the number of species is not very great, but some, like the bat guano mite *Cillibia coprophila*, make up for it in numbers, frequently occurring in millions.

The vast majority of true cave fauna, adapted for life in total darkness, belong to the huge phylum Arthropoda. Worms, both earthworms and planarians, and molluscs have been collected, but nearly always these have proved to come from the surface, although the possibility of finding true cave forms should not be overlooked.

**Crustaceans In Caves**

In the class Crustacea, a species of slater, a terrestrial Isopod, can often be found crawling in dampish places, especially if there is rotting vegetation, and they are quite like the common garden slater. On rare occasions the biologist may be lucky enough to find shrimps or prawn-like crustacea in caves. One such specimen (*Paratya australiensis australiensis*), collected at Buchan in Victoria, is identical with surface forms, and was probably washed in. These aquatic forms are very hard to see, being almost transparent, and are usually observed by the shadow they cast. At least five distinct species have been reported.

It is in the class Insecta that the greatest number of species occur. Many insects are found in association with bat guano, which provides them with food. The smallest insects readily seen are the tiny white delicate springtails (*Collembola*) moving on the surface of the guano, in pools or in wet mud. These tiny insects, about 0·5-1·00 mm. in length, can, by means of special terminal appendages, spring several inches into the air when alarmed.

The False Scorpion, usually found under rocks and loose flakes of stone near guano deposits.

Cave crickets, or Wetas, are curious carnivorous insects which can be found in many of our caves. They occur from the threshold to the deepest parts, and are characterized by their long antennae and large powerful hind legs. The female can be easily distinguished from the male by her strong brownish ovipositor, which is used for depositing the eggs into cracks and fissures in the cave walls.

Several moths occur in caves. The larvae of some build parchment-like cases, decorated and camouflaged by pieces of guano, which also forms their food. These moths can occur in large numbers, and provide food for both Wetas and spiders; their remains are frequently found in the webs of spiders, and Wetas have been observed to stalk them across the guano.

The beetles are well represented, and at least eight families have been recorded. The small brown beetle *Ptinus exulans* is not uncommon in damp guano deposits, and larvae of the other forms, especially the *Carabidae*, can often be found in guano.

Excluding the parasitic forms on bats and the obvious surface species, most of the true flies which occur in caves are small and midge-like.

The class Arachnida is well represented in caves, the most important group being the spiders. Australian caves appear to have quite a number of species. Some of them are orb-web spinners, some make a simple web of numerous strands, and others make a complex funnel-shaped web. It is certain that many species are undescribed, but the best-known is *Mimetus maculosus*, common in the Grand Arch at Jenolan.

Harvestmen, creatures looking rather like spiders at first glance, are not nearly as common as spiders. They differ from spiders in their body structure, and do not spin webs. Harvestmen appear to drink a lot, and are usually found in caves with a good water supply. They are active, and run about the walls looking for prey. *Holonuncia cavernicola* is a well-known Australian form occurring both in Tasmania and on the mainland.

The False Scorpions are small, dorsoventrally flattened creatures usually found under rocks and loose flakes of stone near guano deposits. They are somewhat scorpion-like, but lack the characteristic tail and are rarely more than 10 mm. (about two-fifths of an inch) in length.

Guano and other cave debris provide shelter for the larvae and nymphs of parasitic ticks and both free-living and parasitic mites. The guano mite *Cillibia coprophila* at times may occur in such numbers as to give the guano an appearance of movement.

The final group of animals living, or found, in caves are those which are there by accident. They may be either invertebrates or vertebrates. The invertebrates are chiefly insects which have aquatic larvae, and which have been carried in by streams. At Wombeyan, one of the commonest insects in this group is the May fly. Both adults and larvae have been caught, but damsel-flies, dragon flies, caddis flies and stone flies have also been found.

The remaining animals in caves are obviously accidental visitors and they will almost certainly perish. These visitors include snakes, lizards and frogs, and frequently the cave biologist will come across their decomposing bodies and skeletons.

The study of cave fauna in Australia is still in its infancy, and all information relating to this phase of biology is of great value. Specimens, if collected, should be preserved in 70 per cent alcohol, and fully labelled as to place, date, cave and locality in the cave, as well as with the collector's name. Material can be sent to the author, who will sort it out and send it to the recognized authorities. A special request is made for information on the habitats and locations of insectivorous cave bats in any State of the Commonwealth.

[*Photos in this article are by Mr. Justice F. G. Myers.*]

## ***Fossil Gallery Model***

A preparator and an artist preparing a scale model of the fossil gallery which is being planned for the Australian Museum's new wing, now nearing completion. The gallery is so designed that visitors will see the exhibits in their geological-time succession, and there will be numerous dioramas showing the dominant forms of life in each geological period.

# *THE BITING MIDGES*

By DAVID J. LEE

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MOST of us are familiar with the biting midges (flies of the family Ceratopogonidae) under the common name "sandflies". However, this name is used for an entirely different group of flies elsewhere in the world—the blood-sucking genus *Phlebotomus* of the family Psychodidae which breed in animal burrows and cracks in old masonry. Furthermore, to New Zealanders and people of central Queensland, "sandfly" refers to another family of small biting flies, the Simuliidae, commonly called blackflies in most other parts of the world. These flies are associated with running water, breeding in fast-running streams, waterfalls and flooded rivers.

Since Australians are in the minority in the way the term "sandfly" is misused, the best solution is to fall into line with overseas practice and use "biting midges" when we wish to refer to those minute, irritating biting flies, which, although seldom seen, often inflict bites that have irritating reactions, especially in coastal estuarine areas.

The best-known of the biting midges are commonly associated with mangrove areas, but the tidal reaches of any estuaries usually produce them in great numbers, as also do some beaches on the coastline north of Brisbane and in the Northern Territory.

### Ten Groups In Family

However, the biting midges are a far more diverse family than is commonly supposed. Some ten distinct groups are recognized within the family, and by no means all of these are blood-sucking pests. Some are flower-visiting, many are predatory and suck the blood of other insects, even from the wings of dragonflies or from caterpillars, and others probably live for so brief a period that feeding is unnecessary.

Flower-eating species have only been recognized in quite recent years as important in the pollination of certain plants. A tropical crop, cacao, from which cocoa and chocolate are derived, appears to be dependent for pollination on species of *Forcipomyia* which may breed in moist exudates of this and other plants. Just how important these midges may be in usurping the conventional role of bees cannot be assessed as yet, as the study of this aspect of behaviour is still in its infancy.

There are many and varied forms of predation on both related and quite unrelated insects, and even on certain other arthropods, such as harvestmen. The species associated with dragonflies have all the appearances of being ectoparasitic; when found they are attached to the wings, and even old museum collections of dragonflies have yielded quite a number. Those which derive their nourishment from succulent caterpillars would appear to be taking advantage of a lethargic prey, whereas most of the predatory species "play the game" by attacking other insects capable of reasonably fast movement. A few blood-feeding species are parasites in the social sense in that they attack mosquitoes which have already engorged on animal blood.

Moisture is essential for the development of immature stages; some predatory types are fully aquatic; others, and most blood-sucking species, breed in wet sand at the margin of streams and pools where air, water and sand are equally available at the waterline. This is one of the easiest habitats in which to find a variety of species as larvae. Tree holes also yield a few species, as do rock pools, even very small temporary ones. Moist-soil-breeding species are known, but other terrestrial habitats are under bark on decaying timber, in organic matter as may accumulate in rot holes at the base of trees and, in Europe at least, in the sappy exudates of certain trees.

### World-Wide Genus

Many blood-sucking species belong to the genus *Culicoides*, which is notorious in all parts of the world, including Alaska and other areas adjacent to the Arctic Circle, but excepting New Zealand and many of the smaller Pacific Islands. The most pestiferous, and hence the best-known, species breed in the sandy mud of salt-water estuaries. The more important of these, *C. subimmaculatus* in southern Australia and *C. ornatus* in northern Australia, are intimately associated with the tidal cycle and emerge in swarms from their breeding grounds at the neap-tide period. Hence we may even predict the possibility of meeting an attack in force. There are other species also associated with estuaries which may be lesser pests; their breeding appears to be at the upper (vertical) limits of tidal infiltration, and supplementary rainfall may be required to keep these areas moist for long enough for the midges to breed.

Other species of *Culicoides* attack man in inland areas, but not nearly as obviously as along the coastline and never in the same plague numbers. Special techniques of collection, such as the use of suction light traps at night, often reveal high densities of *Culicoides* in areas where biting midges are reputed not to occur. However, predominantly bird-feeding species often dominate such catches.

Another blood-sucking genus which is particularly interesting because so little is known about it is *Leptoconops*. One species is a springtime pest in sandstone gullies around Sydney, and, although it usually attacks the hairline or part in the hair, it sometimes bites around the eye, causing a "bung-eye" of about three days' duration. The same species may attack animals such as dogs and horses, and concentration of biting inside the ear leads to a distinct thickening of the ear itself. A related species is a well-known pest around Perth, but its seasonal incidence is in the autumn. The breeding places of these species remain one of our unsolved mysteries.

The biting midges have proved difficult to study in the past, and, despite the fact that as blood-sucking flies they could be suspect as vectors of disease, they have received scant attention until recent years. In addition, there has been a long-standing but erroneous belief that small flies could not live long enough to be capable of transmission of parasitic diseases. They are now known to transmit several filarial worms to stock and man, an important virus disease of sheep (blue tongue) and certain protozoan parasites of birds.

In Australia *Culicoides robertsi* is known to cause an allergic dermatitis of horses (Queensland itch). Otherwise the role of biting midges in veterinary medicine remains a suspect one. They will probably prove to be the vectors of onchocerciasis (worm nodule) in cattle, and they have come under suspicion as possible vectors of a virus disease of cattle, ephemeral fever. Although they are not known to transmit human disease in this country, they are currently being investigated as possible vectors of some of the more obscure arthropod-borne virus diseases, at least amongst bird or animal reservoirs of these viruses, if not directly to man. A common belief that the vesicular skin reaction caused by the biting midge results from the laying of eggs beneath the skin has no foundation in fact.

# *RARE WHALE WASHED UP ON SYDNEY BEACH*

An adult male Strap-toothed Whale (*Mesoplodon layardi*) was washed up on Curl Curl Beach (33° 46′ S, 151° 17′ E) near Sydney, New South Wales, on April 3, 1962. In these rare whales, the teeth are reduced to a single pair in the lower jaw, and these peculiarly flattened teeth curve upwards and inwards until they practically meet over the upper surface of the beak-like snout. The total length of this whale, from the tip of the snout to the centre of the posterior edge of the tail flukes, was 17 ft. 2 in., while the tail itself, from the anus, measured 5 ft. 3 in. A barnacle, *Conchoderma auritum*, was found attached to the base of one of the tusks. This Strap-toothed Whale is now registered in the collection of the Australian Museum as M. 8229.—B.J.M.

Research in the laboratory includes the study of specimens with instruments for measuring and recording a variety of characteristics. Here a mineralogist uses a Leitz-Jelley refractometer, which enables the refractive index of a mineral to be determined.

# *SCIENTIFIC RESEARCH AT THE AUSTRALIAN MUSEUM*

**By DONALD F. McMICHAEL**

FROM time to time the research activities of Museum scientists receive a lot of publicity in the press and on radio and television. We read and hear of Museum expeditions to some little-known part of the continent to study the habits and ecology of various animal species and we see pictures of scientists gazing down microscopes at all sorts of curious creatures.

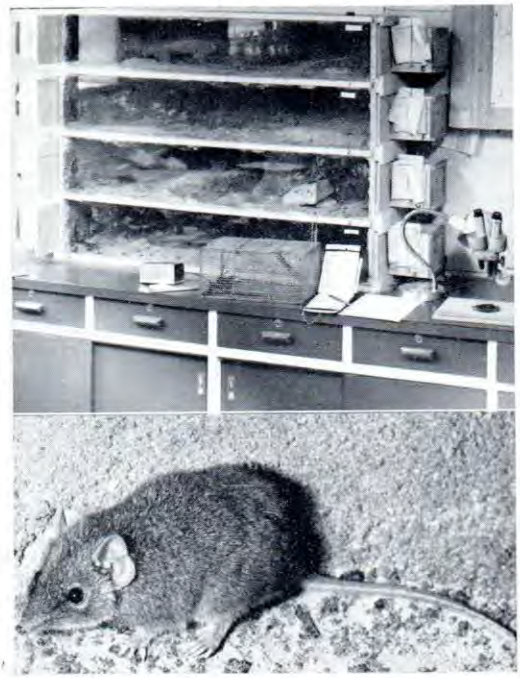
While field studies and microscopic examination of specimens in the laboratory are both important aspects of the Museum scientist's research work, there are many other activities which are normally included in what may be regarded as a typical research project.

Museum research is primarily concerned (on the biological side) with classification and ecology—that is, with the different kinds of animals and the places and conditions under which they live. The first of these, classification, is one of the oldest and most fundamental of all the biological sciences, for classification is one of the things that man does automatically in attempting to understand the world in which he lives. From the very beginnings of time we have classified the objects, both living and dead, which we find in the world, and even primitive peoples sometimes develop quite complicated classifications of living things.

We should at the outset distinguish between identification and classification. The former simply answers the question "What is it?" while the latter attempts to relate the object (be it animal, plant, mineral or stone implement) to other things of a similar kind which we have encountered. Classification involves identification, but that is only the beginning, not the end, of the process. For many years, biologists classifield animals only in the most superficial way, depending on apparent similarities in form to arrive at their groupings. Thus, all shells which had a simple conical shape were regarded as limpets, though in fact this shape of shell has developed on a number of occasions in quite unrelated groups of gastropod molluscs.

Just over a century ago, the whole course of biology was altered by the development of the concept of evolution. Since then, classifiers have realised that the similarities which they found in related animals were not the result of chance or of "original creation" but a direct outcome of evolutionary processes and indicated a definite relationship in the geological past between the species concerned. At the same time it was realised that evolution could lead to very similar end results from very different beginnings, so that animals which looked superficially alike might in fact be quite different in some fundamental way when examined more closely. Thus, the limpet-shape is one which is most successful for shells that live in the surf zone on the seashore and it has evolved several times. A modern classification, then, would place the siphon-shells (Family Siphonariidae) a long way removed from the true limpets, and recognizes that the similarity in their shells is due to evolutionary convergence.

It is this process of analysing the differences and similarities among animals, not only in the external morphological characteristics but in their physiology, behaviour and in innumerable other ways, that is the research work of the professional Museum scientist. This analysis can be carried out with such tools of trade as the microscope, the dissecting scalpel and the measuring calipers, but the modern worker depends on many other methods and techniques to help him reach a soundly based classification which will express the real relationships between the animals he studies. Analysis of his results is, in this electronic age, becoming the task of the computers, for the electronic brain is a much more rapid and reliable instrument for the independent, unbiassed analysis of data than the human brain.



The maintenance of live animals for the study of breeding and development is part of the research carried out in Museum laboratories. Here a number of small Marsupial Mice (*Antechinus flavipes*), one of which is pictured below, are kept in specially constructed cages (top) and regularly observed as part of a study of the biology of the species.

## Nomenclature

Museum scientists are also concerned with the names of animals, which in itself is an area of research quite distinct from that of classification. We can classify things and label them in many ways—some modern workers have proposed that the system of naming animals with latinized names should be replaced by a system of numbers and letters which would be more readily understood by scientists throughout the world in fields other than biology. However, such schemes have never gained much support, and, for the time being at least, we will continue to use the system of latinized generic and specific names which have been in use for over two centuries. The selection of the correct name for a particular species is based on a knowledge of the group concerned and what has already been written about it, and an understanding of the International Code of Zoological Nomenclature, a set of rules laid down to govern the selection of the name to be used. These rules have recently been brought up to date and, it is hoped, standardized for future use, so that we can now work towards a stable set of names for all the animals of the world which will be universally used and understood. Whether such a goal can ever be reached remains to be seen, for even after two centuries we are still apparently a long way from completing the description and classification of the animals of the world. However, we are hopeful that the present generation can make an approach towards this state, and in some groups of animals, especially the birds and the mammals, scientists consider that they have almost completed their task.

Research in the field includes a series of observations on living animals over a long period. Here a small lizard (*Amphibolurus* species) is being measured, after which its other characteristics will be recorded. It will then be released, and later recaptured for further observation.

Having named and classified our animals, the more generally-interesting work can begin. We are all very interested in what animals do, where they live, how they live through their life-cycle, on what they feed, and what their relationships are with other animals and plants which live alongside them. Information of this kind, which is essential to an understanding of the animal's place in nature, can be obtained by work in the laboratory as well as in the field. Museum workers are often carrying out experiments on the behaviour and habits of living animals, which are to be found in a number of the departments of the Australian Museum and which include small marsupial mice, a variety of lizards and snakes, spiders and insects and land snails. Life-cycles can often be successfully studied only in the laboratory, where constant observation can determine exactly the periods of development and methods of egg-laying, hatching and metamorphosis.

**Field Work**

It is in the field, however, that the Museum biologist finds the most fascinating and enjoyable area of research. The "field", to the scientists, includes the whole range of environments inhabited by living organisms; thus, we have in the Museum people who go to the arid deserts, tropical rain-forests, high mountain beech-forests, mallee and eucalypt scrubs, sandy beaches, rocky shores, coral reefs and mangrove-covered mudflats. Some are interested in the subtidal regions, where aqualung and shallow-water dredges are the research tools. Even the ocean depths are a fascinating field for biological research, and many a Museum scientist has spent hours on a rolling oceanographic vessel studying the living creatures which he has dredged up from the sea-floor thousands of feet below.

The tools of the research scientist when he is out-of-doors include the camera, binoculars, materials for the analysis of the environment both chemically and physically (such as pH meters, thermometers, light meters, depth recorders and analytical chemical apparatus), while modern electronic equipment, such as tape-recorders and radiation-detectors, are often of value.

The Museum staff includes several scientists who are not biologists, and their research work is essentially of a different kind. In anthropology, the study of Aboriginal culture involves both the classical techniques of archaeology and the modern analytical methods of the physical sciences (such as the dating of objects by radiocarbon methods). Co-operation between the anthropologists and biologists is often of importance in establishing the food of ancient peoples by the identification of animal remains, while the geologist can provide information on the origin of stones used in implement manufacture.

### Investigation Of Minerals

The Mineralogical Department of the Museum is concerned with the identification and classification of rocks and minerals and with investigations into their chemistry and physical properties. The Museum has always been interested in the study of meteorites, a field which has recently taken on a new interest with the advent of space flights and the possibility of life on other planets. Modern mineralogy demands a wide knowledge of chemical analysis, and involves the use of such modern techniques as X-ray diffraction, spectrographic analysis and differential thermal analysis. With these methods and the latest equipment, the basic structure of minerals is being investigated right down to the atomic level.

This brief account of the research activities of Museum scientists will serve to indicate that much of the research done in museums does not have any obvious direct application to man's economic well-being We are not concerned primarily with such everyday problems as increasing productivity, destroying pests, or curing disease. None the less, it should not be thought that research of the kind described is in any way useless. It is without doubt true to say that studies of this kind have led to discoveries of major importance to mankind, either by showing that certain animals or minerals have certain useful characteristics, or, indirectly, by contributing to knowledge of evolution or of the evolution of cultural systems in primitive communities. This, in turn opens the way to new understanding of whole fields of knowledge from which spring new ideas and new research. It is advances in knowledge of this nature which, in the long run, may prove of the utmost benefit to mankind.

Some of the work done by scientists at the Museum is, however, of direct importance to the community—for example, the identification of insect pests and other harmful organisms. A study of the organisms boring into wharf-piles in the Port of Sydney, undertaken by the Maritime Services Board in co-operation with several Museum scientists, led to the development of methods of treatment which have saved the Board a considerable sum of money. Research into the classification of the snails which transmit the parasites causing liver fluke in sheep has led to a proper understanding of the distribution of the host snails and of potential danger areas. In these and numerous other ways, Museum scientists are able, through their research, to make a contribution to the welfare of the people of Australia.

# THE AUSTRALIAN MUSEUM

## HYDE PARK, SYDNEY

# The Australian Museum

**The Museum is open free, daily, at the following times : Tuesday to Saturday, and public holidays, 10 a.m. to 5 p.m.; Mondays, 12 noon to 5 p.m. (during school holidays 10 a.m. to 5 p.m.); Sundays, 2 to 5 p.m. It is closed on Good Friday and Christmas Day.**

**To students and pupils of schools and colleges special facilities for study will be afforded if the Director is previously advised of intended visits. A trained teacher is available for advice and assistance.**

**Gifts of even the commonest specimens of natural history (if in good condition), and specimens of minerals, fossils, and native handiwork, are always welcome.**

**The office is open from 9.30 a.m. to 1 p.m. and 2 to 4.30 p.m. (Monday to Friday), and visitors applying for information there will receive every attention from the Museum officials.**

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